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SUMMARY OF RESEARCH  
FOR  
MEASUREMENT OF LOW-FREQUENCY  
ELECTRONS AND PROTONS IN THE EARTH'S MAGNETOSPHERE  
AND THE INTERPLANETARY MEDIUM  
WITH IMPs 7 & 8

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## SUMMARY OF RESEARCH

NAG5-295

### INSTRUMENT STATUS

The IMP-7 satellite was launched 26 September 1972 with initial perigee and apogee geocentric radial distances 31.5 and 36.9 Earth radii, respectively. Orbital period was 295 hours and the orbit was inclined 32 degrees with respect to the ecliptic plane. The period of operation for the University of Iowa's LEPEDea instrument was 5 October 1972 until the cessation of spacecraft operations on 31 October 1978. The spacecraft was successfully reactivated for a short period in 1985. The IMP-7 LEPEDea instrument provided excellent plasma data up to the turn-off time.

The IMP-8 (Explorer-50) satellite was launched 26 October 1973. The IMP-8 orbit is geocentric, approximately  $30 R_e \times 40 R_e$ , 12.5 day period (60% in Solar Wind). The period of operations for the LEPEDea instrument began 15 November 1973. The LEPEDea continues to function successfully, although with reduced sensitivity after many years of operation. The instrument response is checked periodically.

### RESEARCH ACTIVITIES

Analyses of data obtained from IMPs 7 & 8 were directed toward two important areas of magnetospheric research: (1) upstreaming ions from the earth's bow shock into the interplanetary medium, and (2) dynamics of the plasma sheet during magnetically quiescent and disturbed periods.

In addition, analyses of simultaneous observations of this phenomena with the ISEE spacecraft were performed.

IMP-8 was the first spacecraft mission to give plasma velocity distributions in the magnetotail, revealing the existence of dynamic boundary regions bordering the plasma sheet. The basic plasma and magnetic topology of the magnetotail discovered by IMPs 7 and 8 was later confirmed by the ISEE and AMPTE spacecraft.

The IMP-8 project made major contributions to our understanding of plasma processes in the magnetosphere. Insight into substorm processes, in particular plasma dynamics, was gained. Case studies of individual events as well as statistical analyses of large numbers of substorms were carried out in order to establish the phenomenology of magnetotail behavior during substorms.

## SPECIFIC ACCOMPLISHMENTS OF IMP-8 LEPEDea ANALYSIS

Multi-satellite studies of substorm processes, involving primarily ISEE and IMP-8, have demonstrated the importance of the boundary layers in magnetotail dynamics (Eastman et al., 1984; Eastman et al., 1985; Huang et al., 1984; Lui et al., 1984; DeCoster and Frank, 1985).

Multi-satellite studies of the plasma sheet boundary layer have demonstrated the dynamical importance of that region out to nearly  $40 R_E$  and have indicated the presence of field-aligned ion beams out to that distance (Eastman et al., 1985).

Simultaneous IMP-8 and ISEE plasma data have shown the magnetotail signatures of substorm activity (Huang et al., 1983).

The discovery of filamentary structures protruding from the plasma sheet or plasma sheet boundary layer into the lobe region is based on simultaneous IMP-8 and ISEE LEPEDea plasma measurements (Huang et al., 1984). These filamentary structures may be the high-altitude signatures of the theta aurora discovered by Frank et al., (1982).

## NSSDC SUBMISSIONS

A complete set of IMP-8 survey slides were submitted to NSSDC for the period from launch through December 1993.

Survey plots were submitted to NSSDC for the entire six-year period of active IMP-7 data accumulation (through September 1978 when the instrument and spacecraft were deactivated).

Archival of the magnetotail periods for 1978 was completed and these tapes were submitted to NSSDC. The tapes contain two-dimensional velocity distributions for ions and electrons. In addition, plasma moments (density, velocity and temperature) derived from the distributions were included. The calibration factors for 1979 were determined and submitted.

The reprocessing of IMP-8 data for all the periods selected for the special ISEE archive (1977-1981, 1983, and part of 1986) was completed. Data were written to magnetic tape and sent to NSSDC.

Ninety percent of the IMP-7 and IMP-8 data for August 1975 through May 1976 is archived.

## PUBLICATIONS

1. Eastman, T. E., L. A. Frank, W. K. Peterson and W. Lennartsson, The Plasma Sheet Boundary Layer, *J. Geophys. Res.*, **89**, 1553-1572, 1984.

The plasma sheet boundary layer during quiet and active periods is characterized on the basis of the plasma velocity distributions. Ions are observed flowing both earthward and tailward, frequently with highly anisotropic pitch-angle distributions.

2. Lui, A.T.Y., D. J. Williams, T. E. Eastman, L. A. Frank and S.-I. Akasofu, Streaming Reversal of Energetic Particles in the Magnetotail during a Substorm, *J. Geophys. Res.*, **89**, 1540-1552, 1984.

A study of plasma and energetic particle observations during a substorm shows that tailward or earthward streaming can be attributed to the spacecraft sampling different regions of the boundary layer. The primary response of the magnetotail appears to be a spatial reconfiguration at the onset of magnetic activity.

3. Eastman, T. E., L. A. Frank and C. Y. Huang, The Boundary Layers as the Primary Transport Regions of the Earth's Magnetotail, *J. Geophys. Res.*, **90**, 9541-9560, 1985.

In the Earth's magnetotail it is established that energy and momentum transfer occur primarily in the plasma sheet boundary layer which is almost always present.

4. Frank, L. A., Plasmas in the Earth's Magnetotail, in *Space Plasma Simulations*, ed. by M. Ashour-Abdalla and D. A. Dutton, D. Reidel Publishing Company, Dordrecht, Holland, 1985; also *Space Sci. Rev.*, **42**, 211-240, 1985.

A review of the general character of the magnetotail plasmas, e.g., plasma domains, flows, temperatures and densities are given.

5. Eastman, T. E., R. J. DeCoster and L. A. Frank, Velocity Distributions of Ion Beams in the Plasma Sheet Boundary Layer, in *Ion Acceleration in the Magnetosphere and Ionosphere*, ed. by T. Chang, AGU Geophysical Monograph 38, pp. 117-126, Washington, D. C., 1986.

Plasma measurements of ion beam velocity distributions are used as a diagnostic tool to evaluate ion acceleration processes in the plasma sheet boundary layer. Two-spacecraft observations show that in certain cases the ion beams have been accelerated through a field-aligned potential drop.

6. Huang, C. Y. and L. A. Frank, A Statistical Study of the Central Plasma Sheet: Implications for Substorm Models, *Geophys. Res. Lett.*, **13**, 652-655, 1986.

The LEPEDea on board ISEE 1 is used to investigate the characteristics of the central plasma sheet under all levels of geomagnetic activity. The results of this study show that the central plasma sheet consists of plasma with high thermal energy (several keV) but low bulk speeds. This remains true

even during high geomagnetic activity. The main effect of increasing activity is heating of the plasma sheet, preferentially at the high-latitude boundaries.

7. Huang, C. Y., L. A. Frank, W. K. Peterson, D. J. Williams, W. Lennartsson, D. G. Mitchell, R. C. Elphic and C. T. Russell, Filamentary Structures in the Magnetotail Lobes, *J. Geophys. Res.*, **92**, 2349-2364, 1987.

Observations made with the IMP and ISEE spacecraft show that filaments protrude from the plasma sheet and its boundaries into the lobe region. These structures are related to polar cap arcs observed at low altitudes.

8. Rostoker, G. and T. E. Eastman, A Boundary Layer Model for Magnetospheric Substorms, *J. Geophys. Res.*, **92**, 187, 1987.

A new model for understanding of substorm phenomenology is presented. Ionospheric signatures near the Harang discontinuity in the auroral oval are compared with field-aligned currents and particle acceleration in the plasma sheet boundary layer.

9. Eastman, T. E., G. Rostoker, L. A. Frank, C. Y. Huang and D. G. Mitchell, Boundary Layer Dynamics in the Description of Magnetospheric Substorms, *J. Geophys. Res.*, **93**, 14411-14432, 1988.

The observational evidence for the dynamical role played by the boundaries of the magnetotail is presented, and the relation to expansive phase onsets of magnetospheric substorms is explored.

10. Frank, L. A., Dynamics of the Near-Earth Magnetotail - Recent Observations, in *Modeling Magnetospheric Plasma*, ed. by T. E. Moore and J. H. Waite, AGU Geophysical Monograph 44, pp. 261-276, Washington, D. C., 1988.

Recent findings from the IMP, ISEE and DE spacecraft are presented and critical questions regarding energy storage and release are discussed.

11. Seon, J., L. A. Frank, A. J. Lazarus and R. P. Lepping, Surface Waves on the Tailward Flanks of the Earth's Magnetopause, *J. Geophys. Res.*, **100**, 11,907-11,922, 1995.

Forty-three examples of ISEE 1 tailward flank side magnetopause crossings are examined and directly compared with the upstream solar wind parameters.